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RESULTS OF FALL 1938 AND SPRING 1939 INJECTIONS IN WESTERN WHITE PINE

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SUBJECT—

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RESULTS OF FALL 1938 AND SPRING 1939
INJECTIONS IN WESTERN WHITE PINE

As a continuation of the injection work in western white pine, a total of 24 trees were injected during the fall of 1938 and spring of 1939. The object of these experiments was three-fold:

(1) to determine the approximate dosage of copper sulphate which is effective in preventing insect attack in trees injected while green and thus ascertain the effective dosage for destroying insect broods in infested trees.

(2) to determine whether there is any difference in results between fall and spring injections.

(3) to check the results of light dosages of copper sulphate in infested trees.

All injections were made by means of the saw-kerf paper-collar method, which is the best and most easily applied technique yet developed for the white pine work.

Effective Dosage for Preventing Insect Attack.

Under this objective, 18 green trees were injected with three different doses of copper sulphate, making six trees for each dosage. The heaviest dose used four ounces of the poison per cubic foot of wood, computing wood volume for only a half-inch shell of outer sapwood. A medium dose of one ounce per cubic foot of wood and a light dose of one-half ounce per diameter inch were the other two dosages used.

No great difference was noticeable in the rate of foliage discoloration of the injected trees. Table I shows the time elapsing from injection to the first evidence of fading.

TABLE I
EFFECT OF DOSAGE ON THE RATE OF
FOLIAGE DISCOLORATION

Dosage	No. trees	Elapsed time (days) injection to first evidence of fading: Range	Mean
4 oz./cu.ft.	6	15-28	22-1/3
1 oz./cu.ft.	6	18-28	21-1/3
1/2 oz./dia.inch	6	22-28	26

It is evident in table I that some of the heavier-dosage trees began fading sooner than trees injected with a lighter dose, but there is little difference in the mean elapsed time.

Although all trees were exposed to insect attack throughout one complete field season, only three of them contained successful bark-beetle attack, excepting of course ambrosia beetles. The remaining trees were either unattacked or unsuccessfully attacked as shown in table 2.

TABLE 2
INSECT ATTACK IN TREES INJECTED WHILE GREEN

Dosage	Tree no.	5	15	25	35	45	55	65	75	85	95	108
	901	ambrosia	ambrosia	0	0	0	0	0	0	0	0	0
	902	ambrosia	ambrosia	0	0	0	0	0	successful *Ips vancouveri*			
4 oz./cu.ft.	903	ambrosia	ambrosia	0	0	0	0	0	0	successful *Ips* and wood borers		
	972	0	0	0	0	0	0	0	0	0	0	0
	973	0	0	0	0	0	0	unsuccessful secondary				
	974	0	0	0	0	0	0	*Monochamus* egg scars				
								0	0	0	0	
	904	ambrosia	ambrosia	0	0	Unsuccessful *Ips* attack						
	905	ambrosia	0	0	0	unsuccessful *Ips* & secondaries a/		0	0	0	0	
	907	ambrosia										
1 oz./cu.ft.		unsuccessful *D.* monticolae			successful secondary attack							0
	969	ambrosia	ambrosia	ambrosia	0	0	0	*Monochamus* egg scars				
								0	0	0		
	970	0	0	Unsucc. *Dm.*	0	0	0	0	0	0	0	0
	971	ambrosia	ambrosia	Unsucc. *Dm.*	0	0	0	0	0	0		
	906	0	0	0	0	unsuccessful *Ips*.			0	0	0	0
		b/ambrosia										
	908	unsuccessful *Dm.*			0	0	0	0	0	0	0	0
	909	0	0	0	0	0	0	0	0	0	0	0
	966	0	0	0	0	0	0	unsucc. secondary	0	0		
1/2 oz./dia.in												
	967	0	0	0	0	0	0	0	0	0	0	
	968	0	0	0	0	0	0	0	0	0	0	0

a/ Other secondaries comprise *Orthotomicus*, *Pityokteines* etc.

b/ This tree was only eight inches away from one heavily attacked by the mountain pine beetle during 1939.

Discounting the attacks by ambrosia beetles, all dosages were in most cases effective in preventing successful insect attack. In the four-ounce group, two trees were successfully attacked in the top, two prevented attack and two were unattacked. In the one-ouncé group, one tree was successfully attacked in the upper stem but prevented successful attack up to 35 feet, while the remaining five trees prevented successful attack. In the light-dosage group, three trees prevented successful attack and three were unattacked. In all of the 18 trees there were some portions unattacked by insects.

At the time of the final examination, increment cores were taken at various points to represent (1) areas of successful ambrosia beetle attack, (2) areas of successful attack by other bark beetles, (3) areas of unsuccessful insect attack, and (4) areas where no insect attack occurred. These cores were sent to the Asheville, N. C., laboratory, where they were analysed quantitatively for copper content by Dr. B. H. Wilford. The results of these analyses are shown in table 3.

TABLE 3

AMOUNT OF COPPER RECOVERED FROM CORES REPRESENTING
SUCCESSFULLY ATTACKED, UNSUCCESSFULLY ATTACKED AND UNATTACKED AREAS

Insect attack	half inch core section	Pounds copper sulphate per cubic foot										
		Core number										
		1	2	3	4	5	6	7	8	9	10	11
			a/									
Ambrosia	outer	.05	0	0	0							
	2d	.03	0	0	0							
	3d	0	0	0	0							
Successful attack	outer	0	0									
	2d	0	trace									
	3d	0										
		a/						a/				
Unsuccessful attack	outer	0	0	0	0	0	trace	0				
	2d	0	0	0	0	0	0	trace				
	3d	0		0	0	0	trace	0				
		a/	a/					a/	a/			
No attack	outer	0	0	trace	0	0	0	.03	trace	0	0	trace
	2d	0	0	0	0	0	0	0	0	trace	0	0
	3d	0	0	0	0	0	0		0	trace	0	0

a/ These cores were taken from areas showing the green-tinged sapwood and tight bark characteristic of a good poison distribution.

It is at once apparent in table 3 that very little copper was recovered from any of the cores. All dosages are equally represented in the total number of cores but not in the number showing the presence of copper residues. Four cores from four-ounce-dosage trees, four from one-ounce-dosage trees and one from the light-dosage trees showed recoverable copper to be present. Of the two cores showing a measurable amount, the one with the greater residue was from a four-ounce-dosage tree and the other from a one-ounce dosage. It is surprising to note the almost complete absence of copper in the seven cores from areas where insect attacks failed to produce broods.

In addition to the above cores, a complete set was taken from one tree in each of the three dosage groups. One core was taken on each of four sides of the tree at ten-foot intervals throughout the total length. The results of the quantitative analyses of these cores are shown in table 4. Only the results from the outer half inch are shown because there were only four cores showing the presence of copper deeper than this.

TABLE 4
COPPER RECOVERED FROM GREEN TREES
INJECTED WITH DIFFERENT DOSAGES

Height of sample	Pounds copper sulphate per cubic foot in outer 1/2 inch of wood											
	Tree 902 dosed 4 oz./cu.ft.				Tree 907 dosed 1 oz./cu.ft.				Tree 909 dosed 1/2 oz./diam. in.			
	Side				Side				Side			
	1	2	3	4	1	2	3	4	1	2	3	4
ft.												
95	0	0	.05	.02					0	0	0	0
85	.05	0	.02	.02					0	0	0	0
75	.05	.05	0	0	0	0	0	0	0	0	0	trace
65	.02	.02	.02	0	0	0	0	0	0	0	0	0
55	.02	0	.02	.02	0	0	0	0	0	0	0	0
45	.02	.05	0	.02	0	0	0	0	0	0	0	0
35	.02	.02	0	0	0	0	0	0	0	0	0	0
25	.02	0	0	.02	0	0	0	0	0	0	trace	0
15	0	0	0	0	0	0	0	0	.02	.02	0	0
5	0	.05	0	.02	0	0	0	0	.02	.02	.02	.02

Only two traces of copper were found beyond 15 feet in the light-dosage tree, no copper at all was recovered from the one-ounce dosage, and a decidedly irregular distribution is apparent in the heavy-dosage tree. Tree 902 contained ambrosia attack up to 15 feet, no attack from 15 to 65 feet and successful Ips attack above 75 feet. Tree 907 showed ambrosia attack and unsuccessful mountain pine beetle attack at 5 feet, unsuccessful mountain pine beetle attack up to 45 feet and successful secondary attack beyond this point. Tree 909 was unattacked by insects.

From the data shown in these tables, the logical conclusion is that the prevention of successful insect attack does not depend on the presence of recoverable copper.

Effectiveness of Fall and Spring Injections

To answer this objective, nine of the 18 trees discussed above (three in each of the three dosage groups) were injected during the fall of 1938 and nine during the spring of 1939. In table 2, the trees numbered from 901 to 909 inclusive are the fall injections, while those numbered from 966 to 974 inclusive were injected during the spring. Table 5 summarizes these results.

TABLE 5
INSECT ATTACK IN SPRING- AND FALL-INJECTED TREES

Time of injection	No. trees	Number of trees showing: Ambrosia att.	successful att. by other insects	unsuccessful attack	No. insect attack a/
Fall	9	7	3	5	2
Spring	9	2	0	6	3

a/ exclusive of ambrosia beetle.

The data indicate that the spring injections were the more successful in preventing insect attack. This is also true in the matter of recoverable copper. Of 12 fall-injection cores analysed only three showed the presence of recoverable copper, while six of 11 cores from spring-injected trees showed some copper to be present.

Light Doses in Infested Trees

Six trees infested with the mountain pine beetle were injected during the fall of 1938 with one-half ounce of copper sulphate per diameter inch. These injections were made 10, 20, 30, 40, 50 and 60 days after attack so that there was one tree in each of the age groups. The mortality secured from these injections as well as the amount of copper recovered in the outer half inch of wood are shown in tables 6 and 7.

TABLE 6
LIVING MOUNTAIN PINE BEETLE BROOD IN INJECTED TREES

Height of sample	Living mountain pine beetle brood per square foot a/					
	Tree number and age of attack					
	910 (10)	912 (20)	913 (30)	911 (40)	914 (50)	915 (60)
ft.						
95				0		
85				0		
75				0		
65	0			0		42.0
55	0	8.0		0		7.5
45	0	17.0		1.0		8.0
35	0	6.0		0	0	1.0
25	0	5.0	3.3	1.0	0	2.0
15	0	2.6	2.0	0	2.0	2.6
5	0	1.6	5.0	0	1.0	1.0

a/ Mountain pine beetle broods in uninjected trees in this area averaged 17.3 per square foot.

TABLE 7
RECOVERABLE COPPER PRESENT IN
CORES FROM INFESTED TREES

Height of sample	Tree number and age of attack																							
	910 (10)				912 (20)				913 (30)				911 (40)				914 (50)				915 (60)			
Side	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ft.	Pounds copper sulphate per cubic foot in outer half inch of sapwood																							
105													0	0	0	0								
95																.02								
85														.02										
75	0	0	0	0 a/																	0	0	0	0
65																								
55					0	0	0	0																
45	.02	.02				.02			0	0	0	0												
35	.02																							
25			.02	.02	.02												0	0	0	0				
15	.02	.02	.02	.02		.02		.05	.02			.02	T											
5	.02	.02			.02	.05	.50	.02	.02	.05	.07	.10							T					.02

a/ Row of ciphers represents height of last sample. Blakk spaces below last sample indicate absence of copper.

Examination of table 6 leaves no doubt that a considerable brood mortality occurred in the injected trees. Out of 37 samples, 17 showed no living brood, 11 contained from one to three living insects per square foot, 7 had from three to eight per square foot, one nearly equaled the average brood for the area, and one far exceeded the average. Tree 910 showed no living brood throughout its infested length and tree

911 contained only two living larvae in an infested length of 95 feet.

Examination of table 7, however, shows that there was very little recoverable copper in these trees except in some of the basal samples. The absence of copper is particularly noticeable in tree 911, which showed such a high brood mortality. It is not possible therefore to offer definite proof that the brood mortality in the injected trees resulted from injection even though it is known that these trees contained average broods at the base when injected and the adjacent check trees contained an average living brood of 17.3 per square foot.

<u>Summary</u>

Twenty-four western white pine trees were injected with aqueous solutions of copper sulphate during the fall of 1938 and spring of 1939 to answer the following questions:

(1) What is the approximate dosage necessary to prevent successful insect attack?

(2) Is there any difference in results between fall and spring injections?

(3) What brood mortality will result from light dosage injections in infested trees during 1938?

To answer the first question 18 green trees were injected with three different dosages of the poison, making six trees in each dosage group. All dosages were approximately equally effective in preventing successful insect attack, although very little copper was found to be present when increment cores taken from these trees were analysed quantitatively.

Nine trees (three in each dosage group) were injected during the fall of 1938 and nine during the spring of 1939, to answer the second

question. Examination of these trees showed the spring injections to have been slightly more effective in preventing successful insect attack.

Six trees infested with mountain pine beetle were injected with a light dosage of the poison. These injected trees showed some brood mortality in all cases, although complete mortality occurred in only one tree.

Fall 1939 Injections

The purpose of the 1939 injections was to make additional tests with two poisons, sodium arsenate and ammonium bifluoride, both of which had given better and more stable results than copper sulphate in previous injections. Since these two poisons are much more toxic than copper sulphate, the dosage used, on the recommendation of Dr. Craighead, was one twenty-fifth of the 4-ounce copper sulphate dosage, or 0.16 ounce per cubic foot of wood. Five trees were injected with each of these two poisons, care being taken that all ten trees were injected on the same day and the same length of time after attack. The saw-kerf paper-collar method of injection was used and all collars were watched until the poison had been completely taken up by the tree.

To be certain of the amount and cause of any mortality which occurs in these trees, a rather complete series of checks was arranged in conjunction with the infestation study. Four half-square-foot samples were taken on each injected tree below the point of injection. From these samples, an anticipated emergence per square foot was calculated for each tree by means of the infestation study robot. In order to check this calculated emergence, 22 infested check trees were sampled

in a similar manner. These will be felled and completely sampled in the spring of 1940 so that the actual emergence can be compared with that calculated from the basal sample. In addition, Buckhorn cages were installed on ten of these check trees in order to check on the accuracy of the basal sample.

As a final check, 12 infested trees in this area were felled and sampled at 20 foot intervals in the usual manner in order to determine the average brood in this area at the time of injection. These trees will be reexamined in the spring of 1940 in order to note any change in the brood status. All of these trees both injected and checks are located close to the creek bottom in the same drainage so that they are approximately under similar environmental conditions. Thus, with this number of check trees, checked and counter checked, one should be able to ascertain a fairly accurate estimate of the brood status in this small area.

To summarize therefore, there are ten injected trees, all injected on the same day and at the same time interval following attack. These injected trees are checked in the following manner:

(1) Basal samples on each injected tree from which has been calculated an anticipated brood emergence for each tree.

(2) Basal samples on 22 trees which will be felled and sampled throughout to check the accuracy of the anticipated emergence figure.

(3) Buckhorn cages on 10 of these 22 trees to check the accuracy of the basal samples.

(4) Twelve trees felled and sampled to ascertain brood status at the time injections were made. These will be resampled in the spring of 1940 to note any change which will have occurred over the winter.